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The Effectiveness of Online Paired Mentoring for Beginning Science and Mathematics Teachers

Linda Simonsen, Jennifer Luebeck, Lawrence Bice

Abstract

In an ongoing multi-state program, computer-mediated communication (CMC) provides a platform for content-based mentoring for beginning science and mathematics teachers. As they engage in the program curriculum, which is enacted almost exclusively online, mentor-mentee pairs also communicate freely in an unstructured private discussion called Pair Place. This study examines the nature and quality of the Pair Place discussions generated by 19 mentor-mentee pairs over the course of an academic year. Content analysis of over 1600 postings reveals noteworthy patterns in the types of teacher knowledge discussed as well as the levels of social co-construction of knowledge achieved. Differences between mentors and mentees as well as between new and continuing mentees in the program are discussed.

Résumé

Dans un programme multiple continu, la communication assistée par ordinateur (CAO) fournit aux enseignants en sciences et en mathématiques débutants, une plateforme pour un mentorat fondé sur le contenu. À mesure qu'ils s'engagent dans le curriculum du programme, lequel se déroule presqu'exclusivement en ligne, les jumelages mentor-mentoré communiquent aussi librement par le biais d'une discussion privée déstructurée appelée la Place des Pairs. La présente étude porte sur la nature et la qualité des discussions à la Place des Pairs générées par 19 jumelages mentor-mentoré au cours de l'année universitaire. L'analyse du contenu de plus de 1600 affichages révèle des tendances qui méritent d'être soulignées concernant les sortes de savoir enseignant discutés de même que les niveaux de co-construction sociale du savoir atteints. Les différences entre les mentors et les mentorés, de même que celles entre les nouveaux mentorés et ceux poursuivant déjà le programme font l'objet d'une discussion.

Introduction

Successful teaching practice requires coherent and sustained teacher development from pre-service preparation through the early years of teaching (Feiman-Nemser, 2001). Pre-service programs alone are not enough; one must be engaged in teaching practice to learn how to teach (Feiman-Nemser & Remillard, 1995). Regardless of their preparation, beginning teachers will inevitably encounter unexpected challenges and unanticipated scenarios that require "just-in-time" knowledge and support. To address these needs, new teachers need support and guidance as they develop toward a state of confidence and professional excellence (Luft & Patterson, 2002; Feiman-Nemser, 2001; Darling-Hammond, 1998).

Teacher induction programs are intended to ease the transition from being a student to becoming a teacher. Induction has been defined as both a process consisting of professional development activities and a phase in the evolution of the teaching career (Feiman-Nemser, Schwille, Carver, & Yusko, 1999). Researchers have shown that carefully planned induction can promote teacher self-reflection about practice (Feiman-Nemser, 2001; Moir & Gless, 2001; Britton, Paine, Pimm & Raizen, 2003). Stansbury and Zimmerman (2002) further observed that the self-reflection developed through mentoring "can lead directly to improved teaching and learning in the beginning teachers' classroom" (p. 5). Linking these two findings suggests that a well designed induction program can increase beginning teacher effectiveness during the early years of his/her career (Moir, Freeman, Petrock & Baron, 2002).

Teacher induction is a multi-faceted process that varies widely from school to school. However, the act of mentoring—assigning an experienced colleague to provide information and support to a novice in the field—is a fundamental component of many programs. Beginning teachers can learn about teaching by thoughtfully interacting with their mentor teachers and internalizing the mentors' experiences (Britton et al., 2003). They may deepen their knowledge of pedagogy, content, and cultural awareness, all found to be important aspects of successful teacher induction (Luft & Patterson, 2002; Feiman-Nemser, 2001; Darling-Hammond, 1998). Emotional support and beginning teacher confidence are also widely cited as key components of successful mentoring (Odell & Ferraro, 1992; Abell, Dillon, Hopkins, McInerney & O'Brien, 1995). Given these broad benefits, mentoring new teachers is a highly desirable practice.

Unfortunately, districts often experience difficulty providing induction and mentoring for secondary teachers. This is especially true in rural states with low population densities and geographically isolated schools. Montana is an excellent example: in many of the state's rural schools, there is only one teacher at each grade level (or multiple grades) in a given content area. The nearest experienced, content knowledgeable mentor may be more than 50 miles away. The problem is only compounded when the unique needs of teachers in specific content areas, such as science and mathematics, are considered. In a 2001 study of southwestern states, Luft and Cox found that only 20% of beginning mathematics and science teachers had access to an induction program of any kind; none of the existing programs addressed issues specific to teaching mathematics and science.

Computer-mediated communication (CMC) offers a potential solution to the challenge of providing quality content- and pedagogy-based mentoring for secondary teachers. In recent years, online learning has been implemented in a widening array of business and academic applications. This may be an ideal approach to supporting teachers in rural and isolated locations; however, an examination of the literature reveals sparse research on "electronic mentoring" via distance learning technologies. In addition to a lack of studies on distance mentoring, the research base that specifically addresses induction for science and mathematics teachers is lacking (Luft, Roehrig & Patterson, 2003). Recent studies do confirm that content-based mentoring supports beginning teachers' content knowledge as well as their understanding of pedagogy specific to their discipline (Britton et al., 2003; Friedrichsen, Chval, & Teuscher, 2007; Luft, Bang, & Roehrig, 2007).

In 2003, an innovative program was jointly developed in Montana and California to address the problem of content-based mentoring for isolated teachers. The program, known as e-Mentoring for Student Success (eMSS), originated as an NSF-funded Mathematics and Science Partnership to explore the feasibility of mentoring beginning science and mathematics teachers in a CMC-based environment. A primary goal of eMSS was to encourage beginning teachers of science and mathematics to move beyond "survival mode" toward a focus on content-oriented professional practice. Since 2003, hundreds of Montana mathematics and science teachers have participated in this online mentoring program, which draws from a unique combination of literature on distance learning and teacher induction.

Purpose of the Study

Analysis of online discourse can yield important information regarding the co-construction of knowledge among discussion participants (Gunawardena, Lowe, & Anderson, 1997; Kanuka & Anderson, 1998; Garrison, Anderson, & Archer, 2001). This study seeks to determine whether private paired discussion between a beginning teacher (mentee) and a mentor in a CMC environment is an effective avenue for social co-construction of knowledge about content and pedagogy among mathematics and science teachers. Specifically, this study focuses on the nature and quality of co-construction of knowledge among teachers interacting in the private paired discussion component of an online mentoring program by examining two questions: (a) How, if at all, does the nature and quality of knowledge co-construction differ among mentors and mentees in the program? and (b) How, if at all, does the nature and quality of knowledge co-construction differ among beginning mentor-mentee pairs vs. continuing mentor-mentee pairs?

Method

Context and Program Description

Research suggests that successful induction programs align professional development curriculum according to the current needs of beginning teachers (Gersten & Dimino, 2001; Valencia & Killon, 1988). With that in mind, initial eMSS activities were aimed at meeting basic pedagogical needs such as creating a productive classroom environment and managing student behavior. However, as beginning teachers began to reach a level of confidence in the classroom, the focus shifted to issues of content and pedagogical content knowledge that would help beginning teachers effectively teach mathematics and science to their students.

In its first year, approximately 70 mentor-mentee pairs from Montana and California participated in eMSS. (The eMSS program continues beyond the original grant funding period and has expanded to include other states; our research addresses only the first two years of the project.) Mentors typically possessed at least five years of classroom experience in the content area of their assigned mentee and evidenced both ability and willingness to interact in online environments. Eligible beginning teachers were new (0 to 3 years experience) to teaching in a secondary science or mathematics content area. A concerted effort was made to recruit beginning teachers of high needs students.

Trained mentors were paired with beginning teachers who taught in the same content area and at a similar grade level. Matching teachers by location was not a primary consideration, since the eMSS induction program functioned almost entirely online, with most activities supported by a CMC environment. The program provided three major avenues for addressing issues of content and pedagogy: instruction, resources, and reflection. The instructional component offered a series of curriculum-based modules that allowed mentor-mentee pairs to explore both pedagogical issues (e.g., managing student behavior, differentiating instruction) and content-specific topics such as facilitating effective labs and using multiple representations. The resource component included links to Web-based tools and materials, access to ready-to-use classroom lessons, and direct contact with university scientists and education experts. Reflection on practice was encouraged in a variety of facilitated and non-facilitated discussions where beginning teachers could ask questions or raise issues with a single mentor or a large peer group.

A variety of group discussion areas were monitored by trained facilitators who implemented strategies designed to promote and improve the quality of the discussions. However, each mentor-mentee pair also had unique access to a private, unstructured discussion known as *Pair Place.* Rather than communicating through traditional email, mentor partners were asked to use this private paired discussion as the primary venue for their discussions related to eMSS. The study described here investigated the nature and quality of co-construction of knowledge between beginning teachers and their mentors based on data from the Pair Place discussions.

Subjects

The source of data for this study is the archived transcripts from academic year 2005-2006, the second full year of the eMSS program. Subjects for the study were drawn from the pool of science and mathematics teacher participants in Montana, who engaged in 39 distinct Pair Place discussions. Mentors were typically assigned to two or even three of the 39 beginning teachers, but each Pair Place discussion was a unique conversation between two individuals.

To guarantee message sequences long enough to allow examination of knowledge co-construction, the number of messages posted by each teacher pair was used as a secondary selection criterion. Specifically, pairs without consistent contact were omitted from the study. These included: (1) pairs who did not communicate at all or exchanged fewer than three messages during Spring 2006; (2) pairs where only the mentor posted messages in Spring 2006; and (3) pairs whose interaction ended before March 2006. Following this culling process, 19 Pair Place transcripts remained in the data pool. Of these, eight pairs taught science and 11 taught mathematics. Eleven of the mentees were new to the eMSS program in 2005-2006, while eight were in their second year of participation. Again, it should be made explicit that while in some cases a single mentor is assigned to two or even three mentees, each of the 19 mentees in the study participated in a unique Pair Place mentor-mentee dialogue.

Data Collection and Analysis

Data for this study are comprised of all (n = 1653) discussion messages posted in the Pair Place discussions by the study subjects during academic year 2005-2006. Following Garrison, Anderson, and Archer's (2001) recommendations, the researchers determined that a single message representing a complete collection of one writer's thoughts would serve as an appropriate unit of data analysis. Complete transcripts of Pair Place discussions were printed and analyzed, and individual messages were categorized under two separate coding systems; (a) knowledge type (*nature*) and (b) evidence of knowledge co-construction (*quality*).

Data analysis began by first coding all messages for evidence of four knowledge types (nature): Life/Logistics (LL), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), and Content Knowledge (CK) (see Table 1). The first three knowledge types are adapted from Schulman's (1987) knowledge typology. The Life and Logistics (LL) knowledge type was defined by the researchers to account for messages that dealt strictly with participants' personal lives or the logistics of navigating the course Web site.

Table 1: Knowledge types (adapted from Shulman, 1987).

Code	Knowledge Type	Message Subject Evidence
LL	Life/Logistics	Personal life situations or logistics of mentoring program
PK	Pedagogical Knowledge	School and classroom issues
PCK	Pedagogical Content Knowledge	Teaching practice within or regarding specific content ...
CK	Content Knowledge	Content knowledge, not teaching of content

Messages that were coded strictly LL (n = 713), meaning the message did not contain any of the other three knowledge types, were set aside and deemed ineligible for quality coding. The following is an example of a message that was coded strictly LL:

> I'm just signing out for spring break. I will be off-line for the better part of a week while yurt camping on the Oregon coast with my family. If you get a spring break I hope you enjoy it. (*LL*)

All remaining messages (n = 940) were coded a second time for evidence of knowledge co-construction by applying a rubric specifically developed for use in analyzing online discourse (Gunawardena, Lowe, & Anderson, 1997). A simplified version of this rubric is summarized in Table 2. This instrument was chosen primarily for its well-defined descriptors of discourse and for its clear focus on the social co-

construction of knowledge. In alignment with interpretations made by Gunawardena et al., any message coded at Phase 3 or above was considered to display indicators of knowledge co-construction (quality).

Table 2: Phases of knowledge co-construction (summarized from Gunawardena, Lowe, & Anderson, 1997)

Phase	Identity	Description
1	Sharing/comparing of information	Statement/observation/opinion
		Agreement/corroborating examples
		Asking/answering questions
		Identifying/defining problems
2	Discovery and exploration of dissonance	Identifying/clarifying areas of disagreement
		Restating positions/advancing arguments
		Referencing experience/data/analogy
3	Negotiation of meaning/ co-construction of knowledge	Negotiating relative weight of arguments
		Identifying agreement/overlap
		Proposal/negotiation/compromise
4	Testing and modification	Testing proposed synthesis against “received fact”/cognitive schema/personal experience/data/literature
5	Agreement and application of new meanings	Summarizing agreements
		Applying new knowledge
		Metacognitive statements illustrating change in knowledge/ways of thinking

Within a given knowledge type, only the highest observed phase of knowledge co-construction was recorded. In other words, a single message might be coded for up to three knowledge types; each knowledge type was then associated with a single numeric code representing the highest phase of knowledge co-construction reached for that knowledge type in that message. The following is an example of a message that received three separate codes for each of the three knowledge types:

> One section in Geometry is finding the area of basic figures. (*CK-1*) I want my students to know more than just the formulas. (*PCK-2*) I have been doing PowerPoint presentations for the notes in each lesson in Geometry. On Thursday my LCD projector wouldn't work. And, I could not figure out which channel my TV was supposed to be on. (*PK-1*)

Inter-rater reliability was tested by comparing the coding results between all three researchers for 133 messages in a pilot study. A statistically significant result (Kappa = .600, $p < .001$) demonstrated acceptable reliability for the coding done in this study. Messages with differential coding were re-examined and discussed until consensus was reached by at least two researchers. Analysis was conducted only after all three researchers agreed upon codes for all messages. For detailed descriptions and representative examples of each knowledge type see AUTHORS (2007).

Discussion of Results

A total of 1653 messages were analyzed from the transcripts of the private paired discussions of the 19 mentor-mentee teacher pairs selected for this study. The majority of messages addressed at least one knowledge type (n = 940); however, messages strictly about Life and Logistics accounted for 43% of the total messages (n = 713). While the focus of this research is on the quality of co-construction within Shulman's knowledge types (1987), the Life and Logistics messages were critical in building trust within the mentor-mentee relationship (Simonsen, Luebeck & Bice, 2007).

Comparison of Mentors vs. Mentees

Mentors posted approximately 42% more messages than mentees (971 vs. 682 messages) in the private paired discussions. However, almost half of the mentor messages (476) were in the Life and Logistics category, representing occasions where mentors were writing to engage their mentee partners on a social level and to encourage them to get involved in various components of the eMSS program. When Life and Logistics is distilled from the message total, it is evident that mentors and mentees were fairly well matched on postings that contained material involving at least one knowledge type (495 vs. 445 respectively).

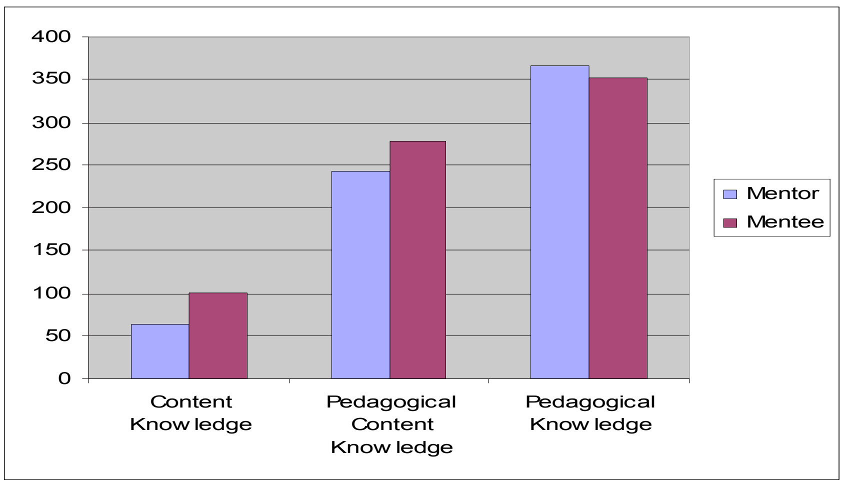
With respect to the *nature* of the private paired discussion, of the 940 messages that were coded by knowledge type, 719 contained material representing pedagogical knowledge (PK), 520 contained pedagogical content knowledge (PCK), and 165 addressed content knowledge (CK) (see Table 3). It is predictable that most of the messages involved some discussion with respect to pedagogical knowledge. We also anticipated the lower percentage of messages that strictly addressed content knowledge. Not surprisingly, discussion of mathematics or science content between mentor and mentee was embedded within the context of teaching, which led to coding messages as PCK rather than exclusively CK. Additionally, there are other venues within the eMSS online mentoring program that support discussion of content knowledge. Content-based Web pages provide resources and ideas for preparing units and addressing specific concepts. Mentees are also encouraged to pose questions about teaching and learning mathematics and science in designated content-based discussion areas, where STEM faculty and teacher educators serve as consultants to answer questions and provide resources.

Table 3: Message totals for each phase of knowledge co-construction by knowledge type

	Knowledge Type		
Phase	Content Knowledge	Pedagogical Content Knowledge	Pedagogical Knowledge
1	128	210	393
2	33	188	238
3	4	109	71
4	0	12	15
5	0	1	2
Total	165	520	719

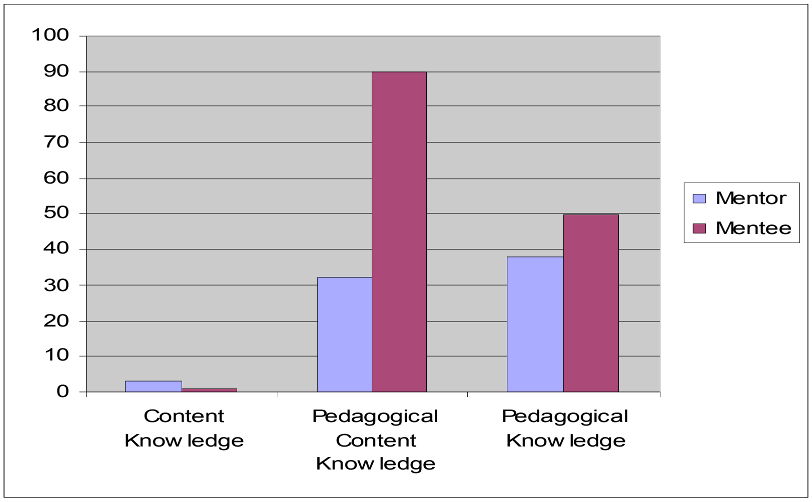
A further breakdown of messages by knowledge type (see Figure 1) reveals that mentors and mentees generally follow similar patterns of communication in terms of what they talk about. This is not surprising; in the natural cadence of a dialogue (online or otherwise), both participants are likely to exchange an equivalent number of messages on the current topic of conversation, be it PK, PCK, or CK. In general, the mentors did not appear to extend interactions beyond the questions they were asked by mentees, limiting the discussion to address the issues at hand.

Figure 1: Comparison of mentor vs. mentee messages by knowledge type.



However, a striking difference is revealed when examining the *quality* of the discussion and restricting the data to reflect only the messages at Phase 3 or higher. Figure 2 displays this subset of messages indicating active co-construction of knowledge. (It is worth noting that we identified very few Phase 5 messages, where newly acquired knowledge is summarized, applied, or metacognitively acknowledged. This is explained by the fact that private paired discussions typically focused on the immediate concerns of the beginning teachers.) Overall, mentee activity in the pedagogical content knowledge category is nearly three times that of the mentors, with a similar but less dramatic result for pedagogical knowledge.

Figure 2: Comparison of mentor vs. mentee messages at Phase 3 or above.



A thorough examination of the message content provides a justification of this phenomenon. Mentors are trained and expected to facilitate the professional growth of their mentees. A typical exchange of messages consists of a mentee asking for information or requesting a solution. Without directly solving the problem, a mentor may suggest a course of action or provide a resource. The mentee then returns to the conversation to report the outcome, which is often indicative of negotiating or testing new knowledge. The following message excerpt demonstrates the final message in such a sequence, where a beginning science teacher is attempting to motivate a student to be successful in his biology class. In preceding messages, the mentee was negotiating ways to address the issue with his mentor's input and feedback. In this message, the beginning teacher demonstrates the testing and modification of the ideas that were previously negotiated. (The mentor responded to this message with a supportive and congratulatory reply.)

> I have been observing an interesting turn of events over the past week … Last week I gave a quiz to all students who had missing work (no missing work, no quiz). When I graded his quiz I was shocked and delighted that he got a 100%. I wrote some comments on it and handed it back the next day. In 12 weeks I hadn't seen the kid smile one time until I handed that quiz back. All the other students around him were shocked and made comments, but he just sat there and smiled. At the end of the week we had a test over the rest of the information. When I graded his test he got a 66% (30% more than he usually gets), but I decided not to give him a 66%. I

> wrote 77% on his paper and gave him a C. For an entire 54 minutes the next day he had a grin from ear to ear. I realize that I probably do him no justice by fudging his grade by ten points [and] I am still in doubt that he will pass anyway ... but I can't wait to see if this change in personality and mentality might help him in other ways. (*PCK–4*)

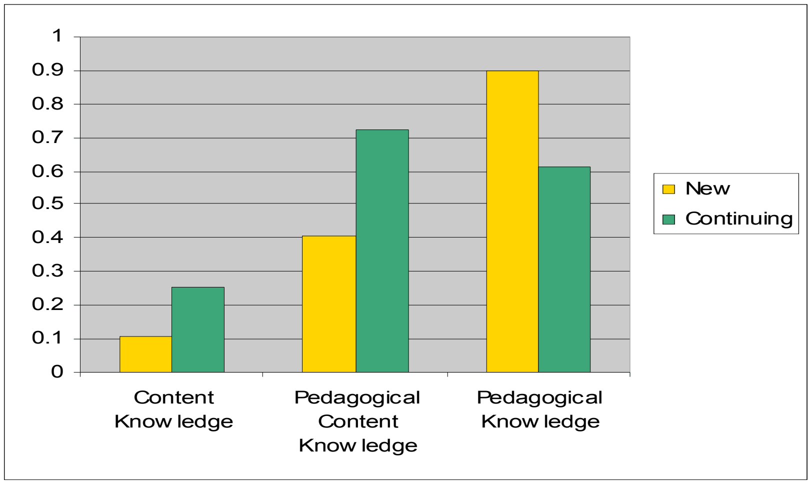
Comparison of New vs. Continuing Mentees

Of the 19 mentor-mentee pairs examined in this study, 11 of the mentees were in the first year of participation in the program (new) and 8 were continuing in the program for a second year. Note that "new" in this context means new to the eMSS program. This typically denotes a first-year teacher, but not always. Beginning teachers with zero to three years of experience were accepted into the program. It is also noteworthy that all of the continuing mentees participating in this study remained partnered with the same mentor they worked with the previous year.

In order to more accurately compare the private paired discussions of the new vs. continuing mentees, the data is represented by percentages. The emphasis on Life and Logistics drops from 48% (469 of 973) for the beginning mentor/mentee pairs to 36% (244 of 680) for the continuing mentor/mentee pairs. The drop in emphasis on Life and Logistics-type messages further supports the claim that Life and Logistics messages are critical to building trust in the partnership (Simonsen, Luebeck & Bice, 2007) since all of the continuing mentees were paired with the same mentor in the second year of the program. The results suggest that in the second year, less emphasis is placed on trust building, allowing continuing mentees and their mentors the opportunity to spend more time on issues of teaching and learning.

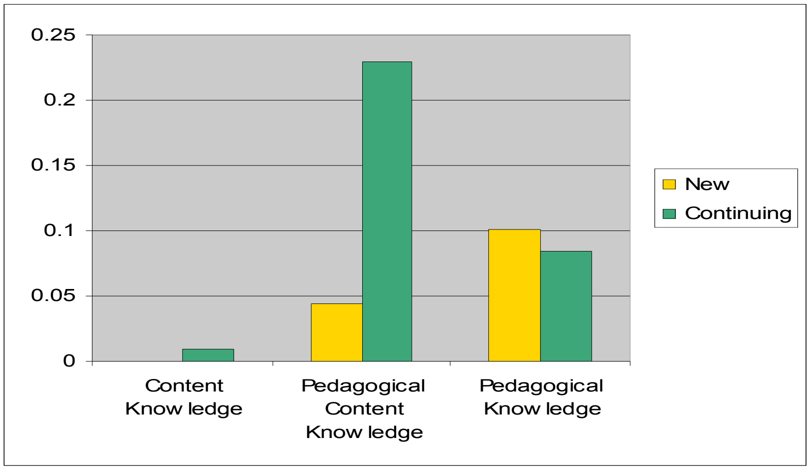
Regarding the *nature* of discussion between new vs. continuing mentees and their mentors, Figure 3 demonstrates a noticeable shift in the primary focus of the messages, from pedagogical knowledge among the beginning pairs to pedagogical content knowledge among the continuing pairs. This finding concurs with previous results (Fieman-Nemser, 2001; Ralph, 2002) suggesting that in a beginning teacher's first years in the classroom, pedagogical concerns related to coping and maintaining control are far more immediate and tend to take precedence over concerns related to content and instructional practice. A new teacher's first year in the classroom is "front loaded" with concerns about managing students, presenting lessons, and handling the logistics of teaching. These more immediate issues naturally take priority over deepening and expanding pedagogical content knowledge, or content knowledge, which is more likely to occur after the new teacher has reached a level of comfort in the classroom.

Figure 3: Comparison of new vs. continuing mentor/mentee messages by knowledge type.



Results on the *quality* of discussion depicted in Figure 4 suggest that the degree of knowledge co-construction between mentors and mentees increased based on years of experience in the eMSS program, especially in the category of pedagogical content knowledge. Twenty-three percent of the PCK messages posted by continuing mentees are at Phase 3 or above, a striking contrast to the 4% of messages indicating knowledge co-construction posted by first-year mentee participants. Evidence of co-construction of knowledge about content knowledge begins to appear, while high-level messages addressing pedagogy alone decrease. These results further support the notion that the beginning teachers shift their concerns as time passes, moving from a narrow focus on generic classroom issues to an expanded exploration of content-related issues.

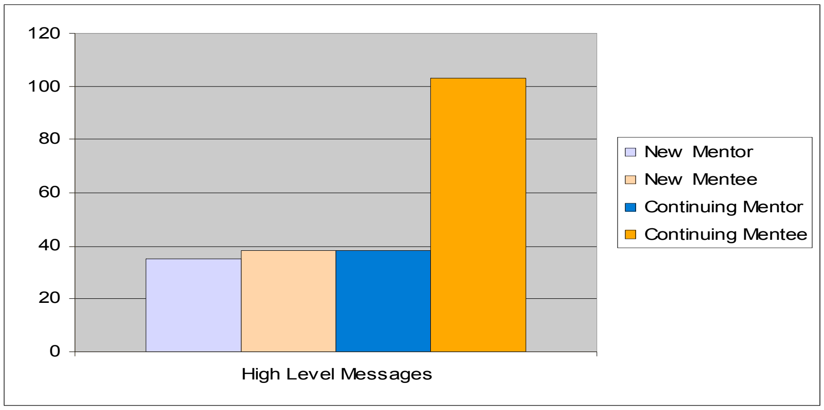
Figure 4: Comparison of new vs. continuing mentor/mentee messages at Phase 3 or above.



Comparative Analysis of Message Quality

It is interesting, though not surprising, that over time, the mentors' levels of knowledge co-construction remained consistent. By contrast, there is evidence of significant growth in the mentees' active co-construction of knowledge between their first and second year in the program as shown in Figure 5. This outcome is consistent with the goals of the mentor training provided by the eMSS program and its definition of a mentor's role. Mentors are trained to facilitate and promote reflection, to provide support without immediately solving problems for mentees, and to be encouraging without taking the lead in discussions. If they are successful, their mentee partners will advance in their efforts to negotiate meaning, test new ideas, and apply newly constructed knowledge.

Figure 5: Comparative analysis of new vs. continuing/mentor vs. mentee at Phase 3 or above.



Conclusions and Implications

Based on the results of this study, one can conclude that beginning teachers who remain in the eMSS program for multiple years experience growth in the process of knowledge co-construction, particularly in the area of PCK. The data also indicate a transition from emphasis on pedagogical knowledge to interest in other aspects of teaching as beginning teachers in the program mature. By contrast, mentors demonstrate consistent levels of knowledge co-construction over two years. This result suggests a steady state in mentors' knowledge of teaching, but it also reflects on their program-sponsored training as facilitators of reflection and inquiry rather than dispensers of knowledge

It is difficult to predict how the transition away from mentor-mentee exchanges about pedagogical issues toward more content-focused concerns would unfold over time. It is also a complex task to separate the effects of participation in the eMSS program from the natural maturation that occurs as beginning teachers gain more experience and confidence. However, the evidence suggests that private paired discussion is an effective venue for exploring and constructing new knowledge about the pedagogical needs and concerns of beginning teachers. In particular, Pair Place is a vital component of the eMSS mentoring program that complements the large-group, content-related, and instructional aspects of the program.

Are there other benefits to be gained through private paired discussion? Based on qualitative analysis of the 713 messages identified as strictly Life and Logistics, we speculate that one advantage of this online mentoring model is the safe haven it provides for discussing sensitive issues. Beginning teachers can interact with mentors who are far removed from the politics of their own local school building or district. With the comfort provided by distance, they are free to talk safely about frustrations with administrators, colleagues, and parents, seeking the advice of experts or simply venting emotions with no fear of reprisal. In addition, the private paired discussion environment appears to successfully support trust building and relationship growth, as mentor-mentee pairs exchange many messages about home, family, and non-teaching-related issues. The results of this study suggest that private paired discussion facilitates a strong bond that links mentees, their mentors, and the classrooms in which they teach.

The beauty of the private paired discussion lies in its ease of replication. Implementation requires only the matching of beginning teachers with a mentor in the same content discipline and access to secure electronic discussion. Whether embedded in an existing induction program or used as a mentoring alternative in a rural school, private paired discussion offers a unique and inexpensive support system for beginning teachers and a means of increasing knowledge of both content and pedagogy through constructive discourse with an experienced colleague.

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Linda Simonsen is an Associate Professor for mathematics education in the Department of Mathematics at the University of Arizona in Tucson. Her research focuses on the nature and quality of mathematical discourse in online settings. This research stems from her extensive work developing Internet courses for place-bound practicing mathematics teachers. E-mail: simonsen@math.arizona.edu

Jennifer Luebeck is an Associate Professor for mathematics education in the Department of Mathematical Sciences at Montana State University in Bozeman. She continues to study Web-based learning and online discussion in the broader context of professional development and mentoring for practicing teachers. E-mail: luebeck@math.montana.edu

Lawrence Bice is a science educator and Assistant Professor and Chair of the Department of Education at Clarke College in Dubuque, Iowa. He is currently transitioning appropriate face-to-face courses to online and hybrid formats, while studying distance based collaborative learning. E-mail: larry.bice@clarke.edu